Homework assignment II

Course: “Performance of Networked Systems”, November-December 2024
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Teacher Assistant: Ritul Satish

I. Traffic Management in IP networks

During the lecture on IP Traffic Management, two important methods to regulate incoming traffic were discussed: (1) *traffic shaping*, and (2) *traffic policing*.

1. What are the main differences traffic shaping and traffic policing?

Let us now assume that the incoming – unregulated – traffic over a 50-seconds time frame looks like the left picture in Figure 1 below.

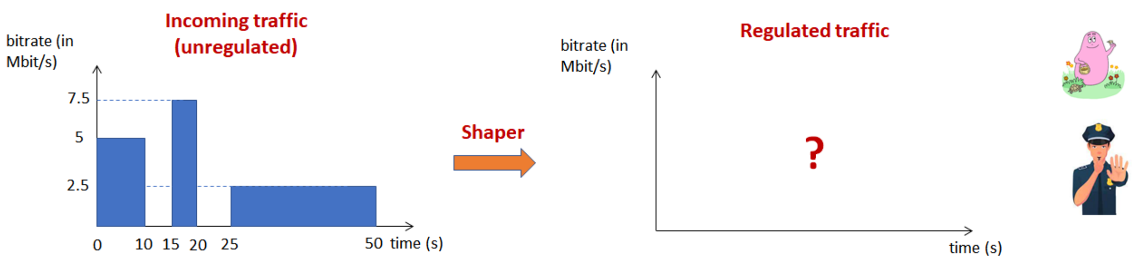

Figure 1: Unregulated traffic (left) is regulated: what does the regulated traffic look like (right)?

We first investigate the impact of *traffic shaping*. As discussed during the lectures, shaping functionality may introduce delay to the incoming traffic stream when the bitrate temporarily exceeds the shaping rate. That is, in terms of a Leaky Bucket (LB) implementation, the “water level” will then rise and introduce delay to incoming traffic.

Assume that the incoming traffic - as in the left part of Figure 1 - is shaped at a peak rate of 3.5 Mbit/s.

2. Make a graph that shows the delay induced by the shaper (i.e., the “water level”) over time. Be precise and motivate your findings.

3. Make a graph that plots the bitrate of the shaped traffic over time. Be precise and motivate your findings.

4. Answer the same question as in questions 2 and 3, but where the shaping rate is now 1.75 Mbit/s (instead of 3.5 Mbit/s).

HINT (for questions 2 to 4): Figure 2 below illustrates the shaping functionality for a simplistic single-burst example, and shows both the bitrate and delay induced by the shaper.

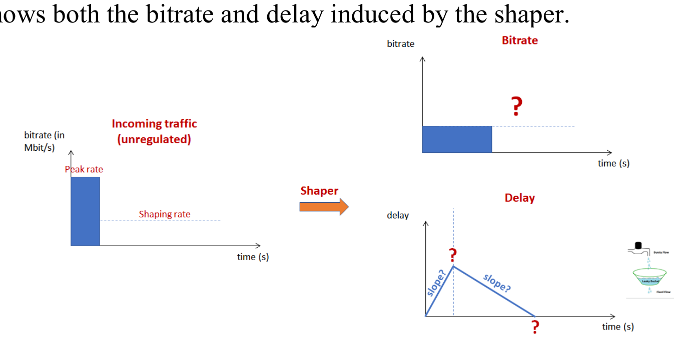

Figure 2: Illustration of the influence of shaping functionality for a single burst.

Traffic policing is a filtering mechanism that checks whether incoming traffic is conforming a Service Level Agreement (SLA), or non-conforming. Recall from the lectures that an often-used implementation of traffic policing is the LB implementation, which is characterized by two parameters: (1) the leak rate r, and (2) the burst tolerance b.

Let us assume that the leak rate of r = 3.5 Mbit/s and the burst tolerance b = 1 Mbyte.

5. Make a graph that plots the bitrate of the policed traffic over time.

Traffic policing is a filtering mechanism that checks whether incoming traffic is *conforming* a Service Level Agreement (SLA), or *non-conforming*.

6. Make a two-colored graph that shows the parts of in coming traffic that are conforming the SLA in **blue**, and the non-conforming traffic in **red**, over time.

7. Answer the same questions as in questions 5 and 6, but where the leak rate and shaping rate are now 1.75 Mbit/s (instead of 3.5 Mbit/s).

II. Performance of TCP-based networks

During the lectures, we have discussed how the TCP protocol works, including the evolution of the congestion window, acknowledgements, TCP Slow Start, etc. See Figure 3 for an illustration.

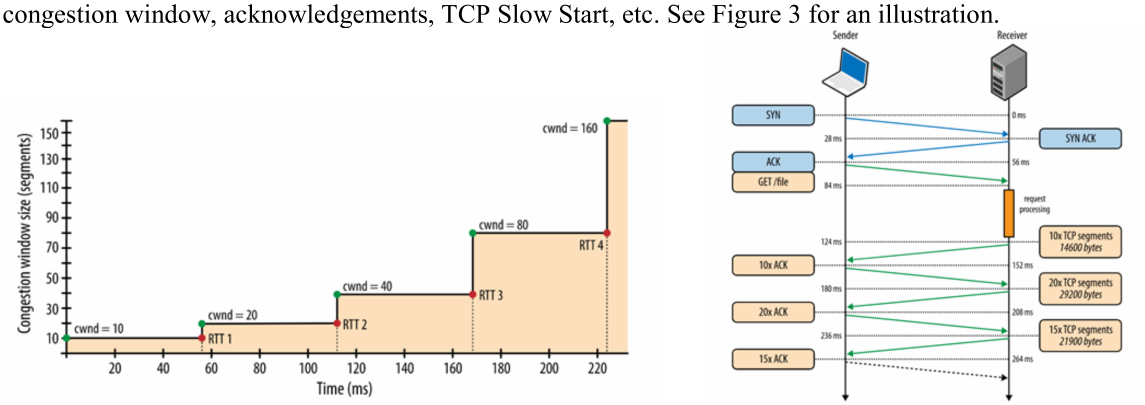

Figure 3: Illustration of the evolution of the congestion window in TCP Slow Start (left) and the acknowledgement process (right) during a TCP file transfer (from the book by Grigorik).

8. What is the main downside of TCP Slow Start?

Suppose that we want to transfer a file from Amsterdam and Atlanta, GA, over a long-distance transatlantic TCP-connection with the following characteristics: RTT = 60ms, receive CW size = 256KB, bandwidth = 200 Mbit/s, MSS = 1460 Bytes, and where the request processing time to generate response = 50ms.

9. For file sizes 15KBytes, 25KBytes and 40KBytes, calculate the transfer time when the initial CW size is 1 segment, assuming that the transfer starts off with a three-way handshake, and is completely processed in Slow Start.

10. Answer the same questions (as in question 8), but now assuming that the initial CW size of the TCP connection is two segments.

11. Answer the same question (as in question 8), but now assuming that the RTT is doubled to 120ms (instead of 60 ms).

12. Use insights obtained in questions 9, 10 and 11 to give a formula that expresses the transfer time (in Slow Start, and including the three-way handshake) in terms of the file size, the RTT, the MSS and the server processing times (both the receive CW size and the bandwidth are assumed to be very large such that they do not play a role).

Hint: see the slides of lectures 4 and 5 and Chapter 2 of the book of Grigorik.

General remark: In addressing all these questions, be clear and motivate the steps you are taking; do not only give plain answers, show 'signs of thinking'.

The deadline is Sunday, December 8, 2024 at 11:59PM. Upload your assignment via CANVAS.

Remarks:
1. The homework can be made by groups of one or two students.
2. If you have question, please feel free to contact Rob (mail: mei@cwi.nl) or Ritul Satish (r.satish@student.vu.nl).
3. The exercises will have been corrected within a few weeks after the deadline. The grades will be posted on the course Web site.
4. Good luck, and most importantly, have fun!